Final Report for Period: 07/2007 - 06/2008
Submitted on: 07/23/2008
Principal Investigator: Lu, Jye-Chyi .
Award ID: 0400071
Organization: GA Tech Res Corp - GIT
Submitted By:

Title:
GOALI: Processing, System Modeling and Process Control for Complicated Functional Data

Project Participants

Senior Personnel

Name: Lu, Jye-Chyi
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kvam, Paul
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Wang, Ni
Worked for more than 160 Hours: Yes
Contribution to Project:
Ni, Jeong and Lu managed to get the wavelet-based SPC paper accepted in IJPR. Now, he is finishing two Ph.D. thesis chapters for paper submissions.

Name: Shen, Cuizhen
Worked for more than 160 Hours: Yes
Contribution to Project:
Cuizhen continues our wavelet-based local random-coefficient model studied by Jeong, Ming and Lu (2006) and develops a Bayesian procedure for thresholding wavelet mean and variance parameters. Key ideas of her research was presented in 2005 INFORMS conference.

Name: Ruan, Lingyan
Worked for more than 160 Hours: Yes
Contribution to Project:
Lingyan helped Dr. Lu to conduct a comprehensive review of literature in the functional data analysis. She is the first year Ph.D. student. Besides her class work, she has developed design of experiment procedures for collecting functional data from reliability degradation testing. She will present her research in an invited presentation in 2006 Spring Research and Quality Conference.

Name: Woo, Hinkyeol
Worked for more than 160 Hours: Yes
Contribution to Project:
Hinkyeol developed an automatic pattern classification tree

based on nonlinear data profiles. The procedure has been tested with data provided by UPS. The decision tree procdure allows us to identify situations that produce unnormal data patterns. For example, troublesome vehicles can be identified for subsequent root-cause analyses in the UPS application.

Name: Park, Soyoun

Worked for more than 160 Hours: Yes

Contribution to Project:

Soyoun is developing data mining procedures for the situation where the number of significant explanatory variables is much larger than the number of observations. Since there are several distinct combinations of explanatory variables leading to the same modeling quality, but having different interpretations. Our current research explores several definitions of model choices for developing procedures to select the unique model under a particular definition with certain physical meaninings.

Name: Mangotra, Divya

Worked for more than 160 Hours: Yes

Contribution to Project:

Divya worked on across-stage manufacturing process modeling and optimization issues. She is partially supported by this NSF grant in her work. Her trip to INFORMS presenting her work is also supported by this grant.

Name: Kim, Sungil

Worked for more than 160 Hours: Yes

Contribution to Project:

Sungil is working on multi-level process modeling, parameter estimation and system optimization research.

Undergraduate Student

Technician, Programmer

Other Participant

Name: Jung, Uk

Worked for more than 160 Hours: Yes

Contribution to Project:

The student serving as a research assistant in the project for finishing a Ph.D. thesis with two chapters. He finished his Ph.D. studies in May 2005. The first chapter develops a wavelet-based random-effect model and a vertical thresholding rule for reducing the data size in multiple curves. The second chapter extends the procedures developed in the first chapter to multiple curves in several classes for balancing the data reduction metric against a ``class-separation'' metric in selecting reduced-size data for decision-making analyses. Two papers have been accepted based on these studies.

Name: Jeong, M.K.

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Jeong continues his Ph.D. thesis work in our laboratory at his new department where he serves as a tenure track assistant professor. Besides managing to publish a paper in the IEEE Trans. on Semiconductor Manufacturing, our team also gets a paper on wavelet-based statistical process control procedures accepted in the International Journal of Productions Research. We also submitted two other papers to IEEE journals. Now, we just finished the first draft of a paper revised for Technometrics.

Name: Na, An

Worked for more than 160 Hours: Yes

Contribution to Project:
She finished her Ph.D. thesis defense in May 2005. Two of her three thesis chapters are supervised by Dr. Lu. One thesis paper is under review and the other is in the final stage of preparation for journal submission.

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

1. Judy Jin, Associate Professor in the university of Arizona
2. Ding Yu, Assistant Professor in the Texas A&M University
3. Shiyu, Zhou, Assistant Professor in the University of Wisconsin.

Activities and Findings

Research and Education Activities:
Research:

1. Develop data-reduction procedures for multiple curves in one class and in several classes for decision analysis unplanned.

2. Develop data-reduction procedures for SPC-type decisions.

3. Develop wavelet-based random-coefficient models for variance-parameter reduction and for spatial-profile data reduction.

4. Develop an integrated mean and variance wavelet thresholding procedure for modeling complicated functional data and for data reduction.

5. Develop classification trees for nonlinear profile data. Applied this procedure to data provided by a company.

6. Develop model selection procedure for the situation where the number of significant explanatory variables is much larger than the number of observations.

7. Develop multi-stage process models for supporting robust parameter design decisions.

Education:

1. Graduated 5 Ph.D. students, where two of them are female. One Ph.D. students passed their thesis proposal exam in Spring 2008. One student passed the Ph.D. screening exam in and two others will take this exam in Fall, 2008.

2. Recruited one new Ph.D. student working on projects in his thesis research.

3. Recruited two new female Ph.D. students in Fall 2006.

4. Taught a data mining class two times with emphasis on wavelet-based functional data modeling and analysis. Taught similar subjects in the statistics in finance class.

Findings:

Besides the publications described in the participant section and the research/education activities described above,

1. We have extendeded the traditional mean-thresholding based data-reduction procedure to both mean and variance thresholding procedures.

2. We have extendeded the classical wavelet-thresholding rules to Bayesian wavelet-thresholding rule and modify it to do data-reductions.

Training and Development:

1. Wavelet-based functional and spatial data modeling skills support us to work with people from several companies near Atlanta area. Experience learned there found that the procedures developed can be useful in mining retail data for marketing purpose and in monitoring vehicle performance for condition-based maintenance.

2. The data-reduction experience learned from the project allows us to expore opportunities in bioinformatics and supply-chain fields from the data-mining perspective.

3. The new experience learned from the research and teaching/thesis-advising activities enables us to develop the state-to-the-art data mining course (now, it is officially approved by the university as a Ph.D. level elective class) and also recruit new companies working with us on a few projects (e.g., data mining in the health insurance system).

Outreach Activities:

Other than talking to perspective clients about data mining

experience in manufacturing and present research/education activities in several international conference (e.g., INFORMS), there is no other outreach activites from the project yet.

Cingular, GE and Enraf have provided us problems and data related to our research. Now, we are exploring wavelet based neural network to handle their complicated problems.

Journal Publications

Jeong, M. K., Lu, J. C., Huo, X., Vidakovic, B., and Chen, D., "Wavelet-based Data Reduction Techniques for Process Fault Detection", Technometrics, p. 26, vol. 48(1), (2006). Published,

Jeong, M. K., Lu, J. C., and Wang , N., "Statistical Process Control Charts for Complicated Functional Data", International Journal of Production Research, p. , vol. , ( ). Accepted,

Jeong, M. K., Lu, J. C., and Yuan, M., "A Wavelet-based Random-effect Model for Multiple Sets of Complicated Functional Data", Technometrics, p. , vol. , ( ). revised paper under review,

W. Zhou, M. K. Jeong, and J. C. Lu, "Data Reduction Method Using a Structured Wavelet Model", International Journal of Production Research, Special Issue on Data Mining for Productions, p. , vol. , ( ). Accepted,

U. Jung, M. K. Jeong, and J. C. Lu, "Manufacturing Informatics: A Vertical-Energy-Thresholding Procedure for Data Reduction with Multiple Complex Curves", IEEE Tans. on Systems, Man, Cybernetics, Part B, p. , vol. , ( ). Accepted,

Fenner, J. S., Jeong, M. K., and Lu, J. C., "Optimal Automatic Control of Multi-Stage Production Processes", IEEE Trans. on Semiconductor Manufacturing, p. 94, vol. 18(1), (2005). Published,

Cuizhen Zhen, J.-C. Lu, and M. K. Jeong, "A Bayesian Mean and Variance Wavelet Thresholding Procedure for Multiple Complicated Functional Data", 2006 INFORMS Conference Presentation Paper, p. , vol. , ( ). paper presented in 2005 INFORMS Conference,

Ding, Y., Elsayed, E. A., Kumara, S., Lu, J.-C., Niu, F., and Shi, J., "Distributed Sensing for Quality and Productivity Improvement", IEEE Trans on. Automatics Science and Engineering, p. 344, vol. 3(4), (2006). Published,

Jung, Uk, Jeong, M. K., and Lu, J.-C., "Data reduction for multiple functional data with class information", International Journal of Production Research, p. 2695, vol. 44, (2007). Published,

Wang, N. Kvam, P., and Lu, J.-C., "Detection and Estimation of A Mixture in A Power Law Process for A Repairable System", Journal of Quality Technology, p. , vol. , (2007). Accepted,

An, N., Lu, J.-C., and Rosen, D., "Supply-Chain Oriented Robust Parameter Design", International Journal of Production Research, p. , vol. , (2007). Accepted,

Jeng, S.-L., Lu, J.-C., and Wang, K., "A Review of Reliability Research on Nanotechnology", IEEE Trans. on Reliability., p. , vol. , (2007). Accepted,

J.S. Fenner, M.K. Jeong, and J.-C. Lu, "Bayesian Parallel Site Model with An Application to Uniformity Monitoring in the Semiconductor Manufacturing", IIE Transactions, p. , vol. , (2007). Accepted,

Lu, J.-C., Jeng. S.-L., and Wang, K., "Review of Statistical and Quality Methods in Nanotechnology", Journal of Quality Technology, p. , vol. , (2008). Submitted,

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

1. Wavelet-based data reduction procedures useful in modeling and analyzing large-size manufacturing enterprise data.

2. Data mining techniques for wide ranges of manufacturing and sensor data.

3. Variable selection for large size of possibly correlated explanatory variables.

Contributions to Other Disciplines:

1. Develop statistical methods for joint mean and variance wavelet thresholding.

2. Develop wavelet-based random-coefficient models useful in statistical and signal-processing fields.

3. Several data-reduction tools are useful in machine-learning and data-mining fields.

Contributions to Human Resource Development:

1. Graduate five Ph.D. students.
2. Advising two M.S. and three Ph.D. students working on the project related activities.
3. One to-be-graduate Ph.D. student found a data mining related job.

Contributions to Resources for Research and Education:

None.

Contributions Beyond Science and Engineering:

None

Categories for which nothing is reported:

Organizational Partners

Any Book

Any Web/Internet Site

Any Product